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CHARACTERIZATION OF InAs QUANTUM WIRES ON (001) InP : TOWARD THE REALIZATION OF VCSEL STRUCTURES WITH A STABILIZED POLARISATION

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Vertical cavity surface emitting lasers (VCSELs) operating at 1.55µm are of great interests in optical telecommunication applications. Their circular, spectral and spatial single mode laser beam is essential points for an efficient fiber coupling and high frequency modulation. Moreover, their low-cost production and the possibility to test each laser directly on the wafer represent great advantages for production applications. In contrast with edge emitting lasers, VCSEL present an important polarization instability [1], which may increase the bit error rate in data transmission. Different solutions have been proposed for controlling the polarization, from patterning the output mirror or by using a birefringent material on top of the mirror, which do complicate the device technology [2-4]. In this contribution, we propose to use a gain material presenting an important polarization anisotropy like quantum wires in order to fix the polarization of the emitting VCSEL.

InAs quantum wires (QWires) have been grown by molecular beam epitaxy (MBE). The optimization of the growth enables the achievement of uniformly sized nanostructures in a high density. QWires dimension have been estimated by atomic force microscopy to be 2.5 nm high, 50nm wide and 0.5-1 µm long (figure 1). Figure 2 is a photoluminescence spectrum of samples containing a single and several layers of optimized QWires. They present a photoluminescence (PL) peak centred at 1.48 µm, close to the 1.55 µm optical telecommunication wavelength. As QWires present a clear anisotropy in dimensions (length is ten times higher than the width), the optical emission is expected to be strongly polarized. Polarization PL experiments have been carried out on conventional quantum wells (QWs) structure and on optimized QWires (figure 3). QWires PL appears to be highly polarized in the [1-1 0] crystallographic direction (polarization factor (PF) as high as 50%), when QWs present a slight difference (PF lower than 10%). QWires efficiency has also been tested by processing wide stripe longitudinal cavity lasers. Excellent properties have been deduced, low infinite threshold current density (90 A/cm² per layer), low temperature wavelength dependence (0.35 nm/K at room temperature).

Apart from the gain region, the realization of VCSEL structures needs to have highly efficient mirrors. As InP based materials present poor performances in terms of reflectivity and thermal conductivity, dielectric materials have been used for the realization of both Bragg mirrors [5]. The dielectric materials used are amorphous silicon and amorphous silicon nitride deposited with a magnetron sputtering system. The active region is made up of lattice matched InGaAs/InGaAsP QWs (or InAs QWires) on (001) InP. The epitaxial layer thickness has been carefully optimised using simulations in order to increase the absorption of the optical pump excitation and to place the QWs (Qwires) to the maximum stationary field. The lower Bragg mirror of 6 periods is deposited directly on the active region. An Au-In eutectic bonding is employed to transfer the sample on a silicon substrate. The InP substrate is removing by mechanical polishing and chemical etching. The process ends by a fine tuning of the cavity, and the deposition of the upper Bragg mirror.

YAG laser optical excitation is used. CW laser emission has been demonstrated when QWs are used for the gain region. The CW lasing operation up to 35°C has been obtained at 1.578µm. The figure 4 shows the lasing spectra at room temperature with a maximum output power of 380µW and a threshold power of about 40kW.cm^{-2}. Like shows in the figure 3, this QWs VCSEL structure presents a randomly oriented and unstable polarisation on the whole samples. When QWires are used for the gain region, very last result do not present yet laser emission, but the VCSEL spontaneous emission is clearly polarized as previously observed with PL.
Those last results are very promising for the realization of a polarization control laser emitting VCSEL for telecommunication applications.

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Figures:

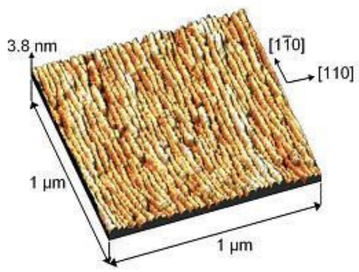

Figure 1 *Atomic force microscopy of InAs QWires on (001) InP*

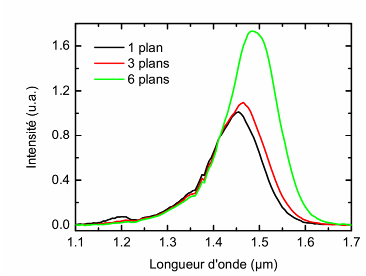

Figure 2 *PL at 1.48µm for different number of InAs QWires layers*

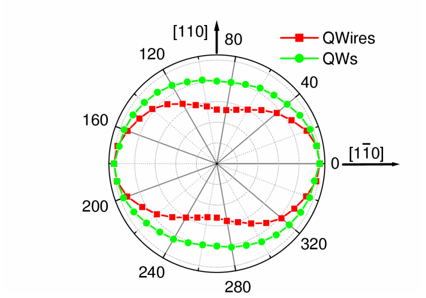

Figure 3 *PL polarised of QWs and QWires*

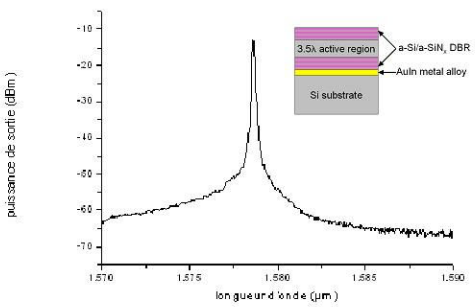

Figure 4 *VCSEL structure reported on silicon and CW laser emissionat RT of a VCSEL with an active region made of QWs.*